N

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F41G 3/04, 5/08

A1

(11) International Publication Number: WO 99/23443

(43) International Publication Date: 14 May 1999 (14.05.99)

(21) International Application Number: PCT/US98/22350

(22) International Filing Date: 22 October 1998 (22.10.98)

(30) Priority Data:
08/962,792 3 November 1997 (03.11.97) US

(71) Applicant: RAYTHEON COMPANY [US/US]; 141 Spring Street, Lexington, MA 02173 (US).

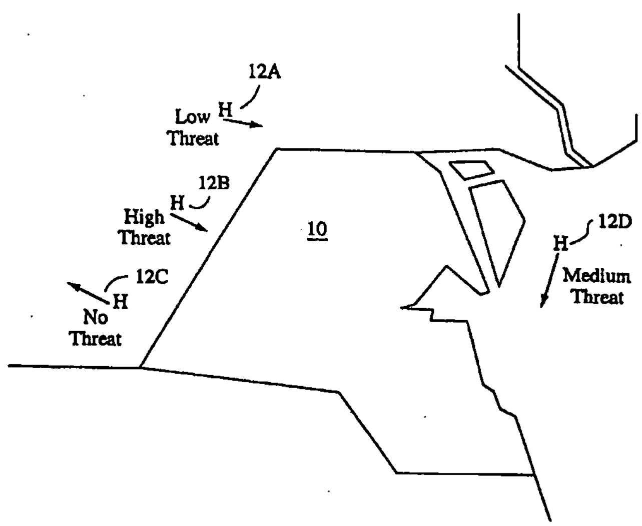
(72) Inventor: BARNES, Gregory, R.; 4971 Berton Circle, La Palma, CA 90623 (US).

(74) Agents: CROWLEY, Judith, C.; Nutter, McClennen & Fish, LLP, One International Place, Boston, MA 02110 (US) et al.

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: KNOWLEDGE BASED AUTOMATIC THREAT EVALUATION AND WEAPON ASSIGNMENT



(57) Abstract

A knowledge based threat evaluation and weapon assignment (TEWA) system and method. Upon identification of a hostile class track, if the track is outside national boundaries or defensive zones, a threat index is calculated to evaluate the threat. The index considers track speed, heading, altitude, and any known amplifying information such as flight size, airframe type, weapons load or missile type. If a threat enters a defensive zone, it becomes a target. Automatically a trial intercept calculation (TIC) will be calculated against the target. The TIC will utilize resources allocated to the zone; and with the aid of a zone target priority knowledge database and a target/weapon pairing database, the TIC will select the best available weapon to neutralize the target. The result of the TIC will be a weapon recommendation to the weapon's controller.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

KNOWLEDGE BASED AUTOMATIC THREAT EVALUATION AND WEAPON ASSIGNMENT

TECHNICAL FIELD OF THE INVENTION

This invention relates to automatic threat evaluation and weapons assignment systems, and more particularly to such a system which incorporates knowledge data bases or expert system techniques in the solution.

BACKGROUND OF THE INVENTION

Automatic threat evaluation and weapon assignment (TEWA) has traditionally been approached in the following representative manner. If an unassigned hostile enters the system, a threat index is computed. The threat index rates the hostile with respect to defended areas and, if a threshold is attained, a trial intercept calculation (TIC) is triggered. There may be several defended areas or the whole country could be considered as one large defended area. The TIC performed typically selects from a list of weapon resources (interceptors and surface to air missiles (SAM) for example), and recommends a set of weapons, ordered by the shortest time to intercept, to engage the target. The intercept problem solved by TIC processing is the time-space problem of placing the target and weapon at the same point in time and space. Once a TIC has been calculated against a target, the target is no longer

evaluated as a threat, since a recommendation has been made to the operator, and automatic TEWA processing is terminated for the target.

This traditional process has shortcomings, and in particular does not address several problems. If information regarding the target (such as type and weapons load) is known, this information is not utilized by TIC processing. The TIC recommends the shortest time to intercept solutions regardless of the target type or defensive weapon type. Hence, it is possible to recommend an interceptor with a weapons load which has virtually no chance of destroying the target. It would be desirable to pair targets with the type of defensive weapons which have a likelihood of destroying the target.

If several hostiles have entered the system, TIC processing does not consider the multiple target problem. That is, TICs are performed one at a time on a target by target basis. Thus, the TIC may recommend a weapon to intercept target number 1 whereas that weapon is most effective against target number 2. In such a situation, it would be desirable to recommend a weapon against the target number 2.

Another problem is that conventional automatic threat evaluation does not account for target maneuver. Consequently upon TIC completion, if the target has maneuvered, the TIC may no longer be valid for the target. Moreover, once a TIC is completed, the target is no longer eligible for automatic threat evaluation processing. This is undesirable in the event of a missed intercept.

SUMMARY OF THE INVENTION

A method for automatic weapon assignment is described, and in an exemplary embodiment comprises the steps of:

(i) providing a database of possible mobile target types, said database including for each target

type a set of particular weapon types in a prioritized arrangement, the target types being assigned a priority ranking;

(ii) providing a target table of targets detected within a protected area;

(iii) selecting a detected target in the target table having a highest priority ranking;

(iv) performing a automatic weapon assignment process on the selected target, the process including selecting an available weapon for use against the target according to the prioritized arrangement, and performing a trial intercept calculation on the target using the selected weapon.

The automatic weapon assignment process of step (iv) further comprises determining whether the selected target has been neutralized by the selected weapon, selecting another available weapon for use against the target according to the prioritized arrangement, and performing a trial intercept calculation on the selected target using the next available weapon.

The method can further include the step of adding newly detected targets within the protected area to the table, and removing from the table any targets which have been neutralized or which exit the protected area.

According to a further aspect of the invention, the protected area is divided into defensive zones, and separate target tables and zone target priority knowledge databases are maintained and used.

BRIEF DESCRIPTION OF THE DRAWING

These and other features and advantages of the present invention will become more apparent from the following

detailed description of an exemplary embodiment thereof, as illustrated in the accompanying drawings, in which:

FIGS. 1 and 2 respectively illustrate the first and second stages of a TEWA problem.

FIG. 3 illustrates a zone target priority database in accordance with the invention.

FIG. 4 illustrates a target/weapon pairing knowledge database in accordance with the invention.

FIG. 5 is a simplified flow diagram illustrating an automatic TEWA algorithm in accordance with the invention.

FIG. 6 is a flow diagram illustrating the target control processing step of the algorithm of FIG. 5.

FIG. 7 is an exemplary zone target table in accordance with the invention.

FIG. 8 is a flow diagram illustrating the automatic TEWA trial processing step of the algorithm of FIG. 5.

FIG. 9 is a flow diagram of the automatic TEWA trial intercept calculation (TIC) step comprising the process of FIG. 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The TEWA process is divided into two stages, according to one aspect of the invention. The first stage evaluates threats as they approach national boundaries. The second stage commences upon the threat entering any of a defined set of defensive zones. If target identification knowledge includes target type and weapons load, this is incorporated into the auto TEWA solution. If the threat includes multiple targets, the entire set of targets is considered. Events such as target maneuver, identity change, missed intercepts and effective engagements are also considered in accordance with a further aspect of the invention.

First Stage FIG. 1 illustrates the first stage. Upon identification of a hostile class track, if the track

is outside national boundaries or defensive zones, a threat index is calculated to evaluate the threat. The index considers track speed, heading, altitude and any known amplifying information such as flight size, airframe type, weapons load or missile type. In FIG. 1, the national area 10 has several hostile tracks 12A-12D adjacent its boundaries. Track 12A is classified as low threat, 12B as high threat, 12C as no threat, and 12D as medium threat.

<u>Second Stage</u> FIG. 2 illustrates the second stage. If a threat enters a defensive zone, it becomes a target. In the example of FIG. 2, hostile track 12E has entered defensive zone 2 of the national area 10. Automatically, a trial intercept calculation (TIC) will be calculated against the target 12E. The TIC will utilize weapon resources allocated to the zone; and with the aid of a Zone Target Priority Knowledge Database and a Target/Weapon Pairing Knowledge Database (described below), the TIC will select the best available weapon to neutralize the target. The result of the TIC will be a weapon recommendation to the weapons controller. If the recommended weapon is a SAM, e.g. SAM 14, and the system is in automatic SAM engagement mode, a pending engagement will be created between the target and selected SAM fire unit. After a time delay, if no operator intervention occurs, the engage command will automatically be transmitted to the fire unit.

<u>Defensive Zones</u> Defensive zones are described by convex polygons. They can lie within the national boundaries or extend beyond national boundaries. For example, FIG. 2 shows defensive zones 1-4. Associated with each defensive zone are weapon resources allocated for zone defense. Weapons can include, for example, SAM sites, aircraft on station at designated Combat Air Patrol (CAP) points or squadrons at designated air bases. Also associated with each zone is a Zone Target Priority Knowledge Database.

Zone Target Priority Knowledge Database This database includes all known possible targets, including an unknown category, and a priority rating associated with each defensive zone. An example database 20 is illustrated in FIG. 3. The assigned priorities may vary as a function of the zone. This allows for the possibility that a target (e.g. of a specific type or with a given weapon load) may be more threatening, or more effective against assets, within the one zone or the other. If a threat or multiple threats enter a zone, the assigned priority indicates the order in which trial processing and, consequently, weapon resources will be allocated to each threat in TIC processing. For example, the first target type in the table of FIG. 3 is a MIG X-L3, where MIG X indicates an aircraft type and L3 indicates a particular type of weapons load. This target type is assigned a zone 1 priority rating of 2, a zone 2 priority of 1, and no priority for zones 3 and 4. A MIG Y aircraft is assigned a zone 1 priority of 1, a zone 2 priority of 2 and no priority for zones 3 and 4. A HELO Z, representing a helicopter type, is assigned a priority 3 for zones 1 and 2, and no rating for zones 3 and 4. The unknown target is assigned a zone 1 priority of 3, a zone 2 priority of 3, and no priority for zones 3 and 4.

Target/Weapon Pairing Knowledge Database This database pairs each weapon resource, in priority order, with each expected target type. This pairing represents the best weapon resource to be employed against the target type. FIG. 4 illustrates an exemplary target/weapon pairing knowledge database 30. In the first row of FIG. 4, the target type is MIG X-L3, the most effective weapon against this target is the F16-L1, the next most effective is the F16-L2, and the last priority is IHawk. The FIG-16 can represent an interceptor type, with L1 and L2 indicating types of weapons load. The IHAWK can represent a SAM type. Similarly, interceptor and SAM types are assigned

priority ratings to each of the other target types. This knowledge is utilized in TIC processing.

Auto TEWA Algorithm An exemplary automatic TEWA algorithm 100 is represented in FIG. 5. This algorithm incorporates the Zone Target Priority Knowledge Database and the Target/Weapon Pairing Knowledge Database to select the highest priority target, from all targets within a zone, and pair it with the best weapon resource available for the zone. The algorithm examines all targets within a zone and accounts for target flight size. If targets become uncommitted, as a result of missed intercepts or ineffective SAM engagements, new trial intercepts will automatically be calculated against the targets. The auto TEWA algorithm includes the Target Control process 110 and the Auto TEWA Trial process 120. Thus, in a general top level sense, the auto TEWA algorithm 100 commences at step 102, and proceeds to the target control 110 to update the zone target table. (The target control process is more fully described below with respect to FIG. 6.) If all the target tables are determined to be empty (step 112), the algorithm stops. If all the target tables are not empty, processing proceeds to the Auto TEWA Trial Process (step 120), and subsequently branches back to step 112. (The process 120 is described more fully below with respect to FIG. 9.)

Target Control Target Control processing 110 creates and updates the Zone Target Table (FIG. 7), and is represented in FIG. 6. This process provides for events causing tracks to be added or removed from the table. Targets are added to the Zone Target Table (steps 110A, 110B) in the following cases:

1. A new uncommitted threat enters the zone.

2. The operator requests automatic trial processing on the target.

3. A target within the zone becomes uncommitted against (SAM broke engagement, intercept missed and

operator recommits fight to another target or return to base).

Targets are removed from the Zone Target Table (steps 110C, 110D) in the following cases:

1. The target is committed against.

2. Weapons have been recommended against the entire target flight size.

3. Operator requests removal.

4. Target is identified as friendly.

5. Target exits zone. (In this case, if it enters another zone, it will be added to that zone's table).

6. Target is neutralized or dropped.

The Zone Target Table is re-prioritized (step 110E) in the event that the type is modified for a target in the table. For example, if a MIG X-L3 is updated to a MIG Y or an Unknown is identified.

Zone Target Table FIG. 7 shows an exemplary Zone Target Table 40. This table is constructed and updated for each defensive zone. As threats enter a zone, they are automatically added to the table and prioritized. This table defines the target order for TIC processing and the weapon allocation to be employed to place the best weapon against the highest priority target. Thus, for example, the first row of the table 40 lists the target type (MIG X-L3), the priority weapon types (first priority is the F16-L1, second is the F16-L2, third is the IHAWK, and so on), and the target priority for the particular zone, in this case zone 4 (second priority). All possible target types are listed in this table.

Operator Requests An operator may request that a target be made eligible or re-eligible for automatic TEWA processing for a variety of reasons. For example, once a trial has been completed on a target and a weapon recommendation made (for entire flight size), the trial processing

will not perform further trials on the target. However, the target may begin to maneuver rendering the recommended weapon no longer effective against the target. Upon target maneuver, detected by the surveillance function, a target maneuver alert will be displayed for the target. The operator may request that automatic TEWA be performed against the target.

Auto TEWA Trial Processing Auto TEWA Trial processing 120 provides for processing a TIC against each target in the Zone Target Table. This is performed in all defensive zones. FIG. 8 illustrates this processing. The processing commences at step 120A, a decision block as to whether all zones have been processed. If affirmative, the processing is stopped at step 120B. If all zones have not been processed, a zone is selected at step 120C. If the target table for that zone is empty, processing branches back to step 120A. If the target table for the selected zone is not empty, then at step 120E the highest priority target for that zone is selected at step 120E using the zone target priority knowledge database of FIG. 3, and the Auto TEWA TIC Control process is performed at step 120F, described more fully in FIG. 9. After completion of the process 120F, step 120G returns the processing to step 120E if all targets in the selected zone have not been processed, or returns to step 120A if all targets have been processed.

Auto TEWA TIC Control Auto TEWA TIC Control (step 120F) provides for the actual trial intercept calculations after the highest priority target has been selected, and is illustrated in the flow diagram of FIG. 9. The actual trial calculations utilize the prioritized weapon resources from the zone target table and calculate whether the weapon can intercept the target. The processing pairs a weapon to each member of the target flight size. If enough weapons of one type are not available, the algorithm examines the

next highest priority weapon. The process continues until all members of the flight size are accounted for (neutralized). If only a partial flight size can be neutralized, an unaccounted (flight not neutralized) alert is displayed to the operator along with the weapon recommendations for the successful intercept solutions. If no intercept solution is found, the operator is alerted by the Trial No Go alert. The target remains in the table and is reexamined as weapon resources become available. Weapon resources become available in the following manner.

1. A SAM site breaks engage with a target and reports a status of ready.

2. A weapons controller recommits a fight from an intercept mission to a combat air patrol mission.

4. The weapon availability at an air base, e.g., is updated to reflect additional aircraft are available.

Referring now to FIG. 9, at step 132, the next highest priority weapon for the selected target is selected, using the target/weapon pairing knowledge database of FIG. 4. If the weapon is not available (step 134), and if all the weapons have not been examined (step 136), operation loops back to step 132 to select the next highest priority weapon. If all the weapons have been examined (step 136), processing proceeds to step 138. Here, if no solutions have been found, a "trial No Go Alert" is established (step 140), and the processing stops. If a solution has been found, a "solutions/flight not neutralized" alert is displayed to the weapons operator (step 146), and the processing stops. If, at step 134, the selected weapon is available, a Trial Intercept Calculation is performed for that weapon asserted against the selected target. If (step 144) the TIC results in neutralizing the target flight size, processing proceeds to step 146. If the flight size

is not neutralized by the TIC, operation loops back to step 136 to determine if other weapons are available.

The Auto TEWA process in accordance with the invention provides for:

1. Two stage threat evaluation;
2. If target identification and weapons load is known, the highest priority weapon to intercept the target;
3. Re-evaluation in the event of missed intercepts;
4. Re-evaluation in the event of target maneuver;
5. Solution of the multiple target problem.

The Target/Weapon Pairing Knowledge Database defines the highest priority, most effective, weapon to counter expected threats. This pairing is based solely upon weapon effectiveness against a target. All weapons capable of destroying the target are prioritized against the target. Some weapons may be equally effective against different targets and some target's priority may vary as a function of defensive zone. For these reasons, the Zone Target Priority Knowledge Database is introduced. The Auto TEWA algorithm processes targets in priority order. This insures that the best available weapon is paired with the highest priority target.

It is understood that the above-described embodiments are merely illustrative of the possible specific embodiments which may represent principles of the present invention. Other arrangements may readily be devised in accordance with these principles by those skilled in the art without departing from the scope and spirit of the invention.

CLAIMS

What is claimed is:

1. A method for automatic weapon assignment, comprising the steps of:

(i) providing a database of possible mobile target types, said database including for each target type a set of particular weapon types in a prioritized arrangement, said target types being assigned a priority ranking;

(ii) providing a target table of targets detected within a protected area;

(iii) selecting a detected target in said target table having a highest priority ranking;

(iv) performing a automatic weapon assignment process on said selected target, said process including selecting an available weapon for use against said target according to said prioritized arrangement, and performing a trial intercept calculation on said target using said selected weapon.

2. The method of Claim 1 wherein said automatic weapon assignment process of step (iv) further comprises determining whether said selected target has been neutralized by said selected weapon, selecting another available weapon for use against said target according to said prioritized arrangement, and performing a trial intercept calculation on said selected target using said another available weapon.

3. The method of Claim 1, further comprising the step of adding newly detected targets within said protected area to said table, and removing from said table any targets

which have been neutralized or which exit said protected area.

4. The method of Claim 1 wherein said mobile targets are airborne targets.

5. A method for automatic weapon assignment, comprising the steps of:

(i) dividing a protected area into a plurality of defensive zones;

(ii) for each defensive zone, providing a zone target priority knowledge database of possible mobile target types, said zone database including for each target type a set of particular weapon types in a prioritized arrangement, said target types being assigned a priority ranking;

(iii) for each defensive zone, providing a target table of targets posing a threat to said zone;

(iv) selecting a defensive zone;

(v) for the selected defensive zone, selecting a target in said corresponding zone target table having a highest priority ranking;

(vi) performing a automatic weapon assignment process on said selected target, said process including selecting an available weapon for use against said target according to said prioritized arrangement in said zone target priority knowledge database for the selected zone, and performing a trial intercept calculation on said target using said selected weapon;

(vii) repeating steps (v) and (vi) for each target in said zone target table; and

(viii) repeating steps (v), (vi) and (vii) for zone until all zones have been processed.

6. The method of Claim 5 wherein said automatic weapon assignment process of step (vi) further comprises determining whether said selected target has been neutralized by said selected weapon, selecting another available weapon for use against said target according to said prioritized arrangement, and performing a trial intercept calculation on said selected target using said another available weapon.

7. The method of Claim 5, further comprising the step of adding newly detected targets posing a threat to a defensive zone to a corresponding zone target table, and removing from a zone target table any targets which have been neutralized or which exit said zone.

8. The method of Claim 5 wherein said mobile targets are airborne targets.

FIG. 1

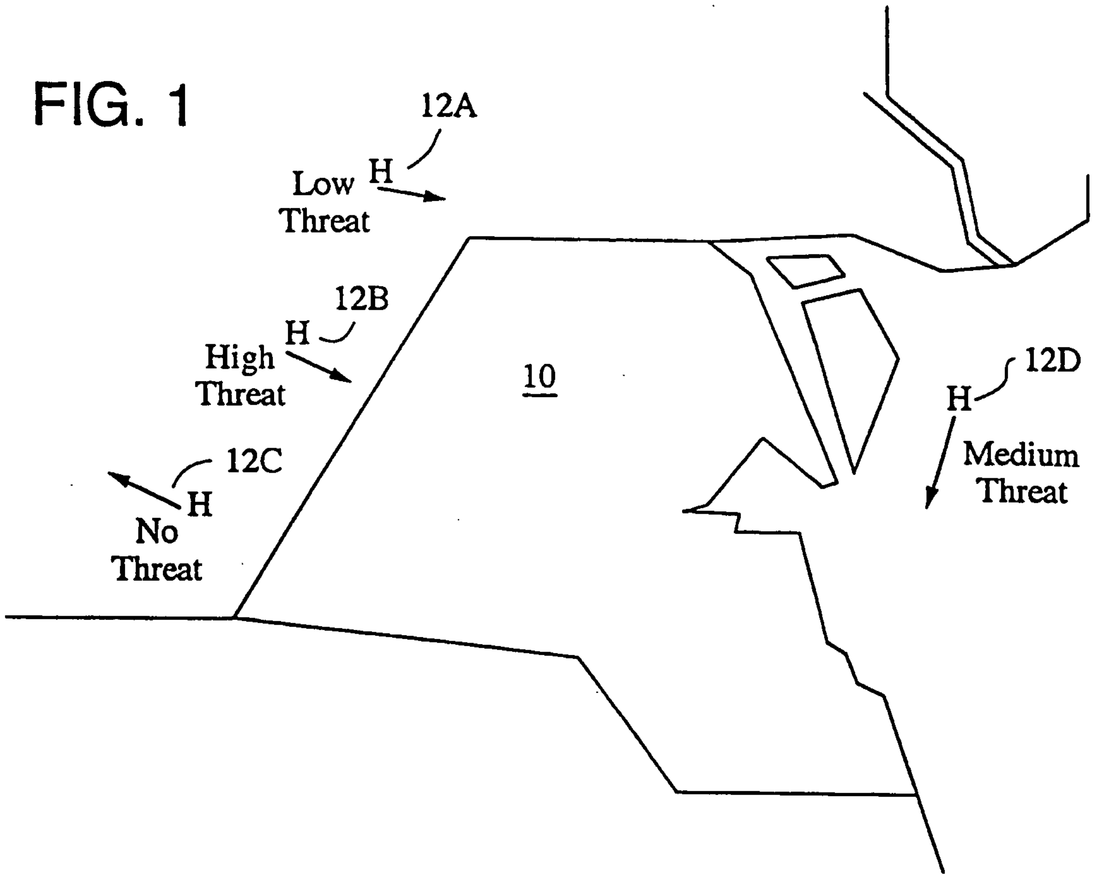
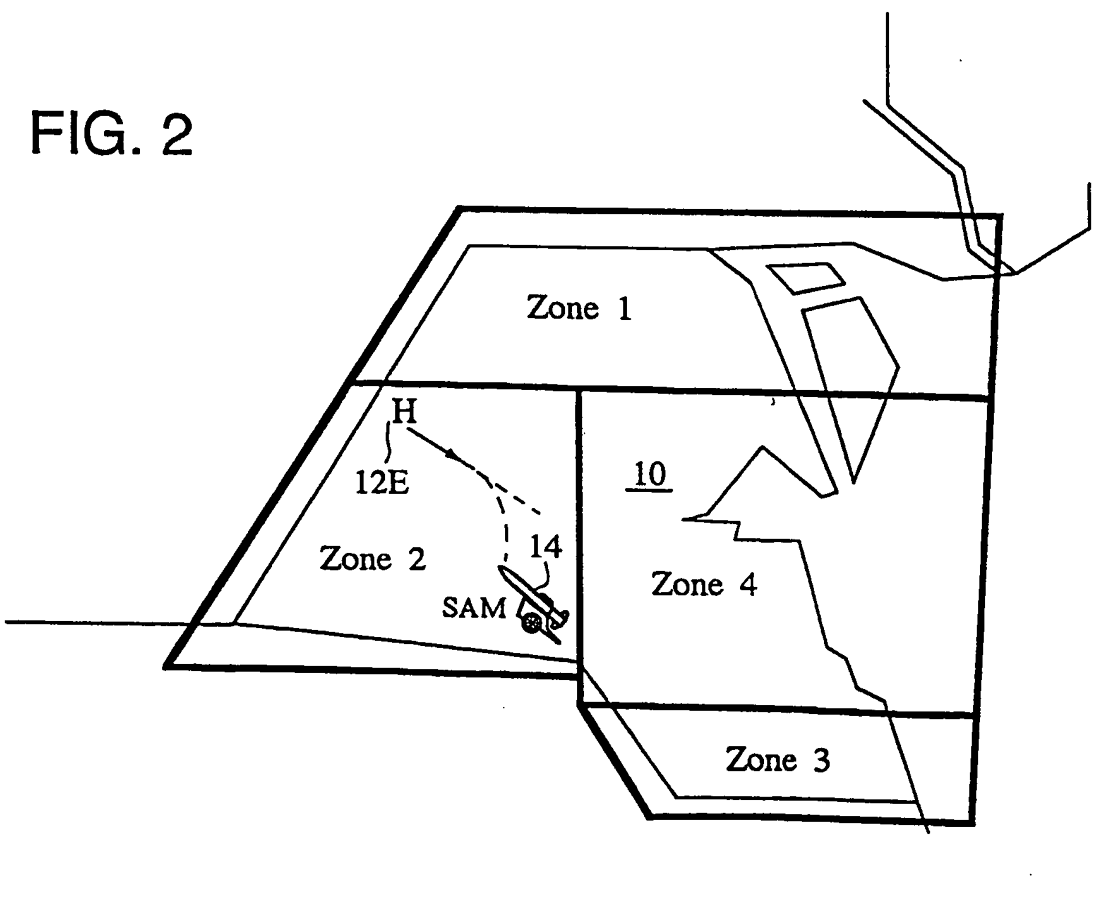

12A
Low
H
Threat
12B
H
High
Threat
10
12D
H
Medium
Threat
12C
H
No
Threat

FIG. 2


Zone 1
H
12E
10
Zone 2
14
SAM
Zone 4
Zone 3

Target Type	Zone 1 Priority	Zone 2 Priority	Zone 3 Priority	Zone 4 Priority
MIG X-L3*	2	1	•	•
MIG Y	1	2	•	•
HELO Z	3	3	•	•
•				
•				
•				
Unknown	4	3	•	•

List All Possible Target Types

20

* Ln Designates Type of Weapons Load

FIG. 3

FIG. 4

Target Type	Priority 1	Weapon 2	Types 3	• • •
MIG X-L3	F16-L1	F16-L2	IHAWK	• • •
MIG Y	F16-L2	F16-L1	PATRIOT	• • •
HELO Z	F16-L2	F16-L1	IHAWK	• • •
•				
•				
•				
Unknown	F16-L2	F16-L1	IHAWK	• • •

List All Possible Target Types

30

List All Possible Weapon Types Capable of Destroying the Target

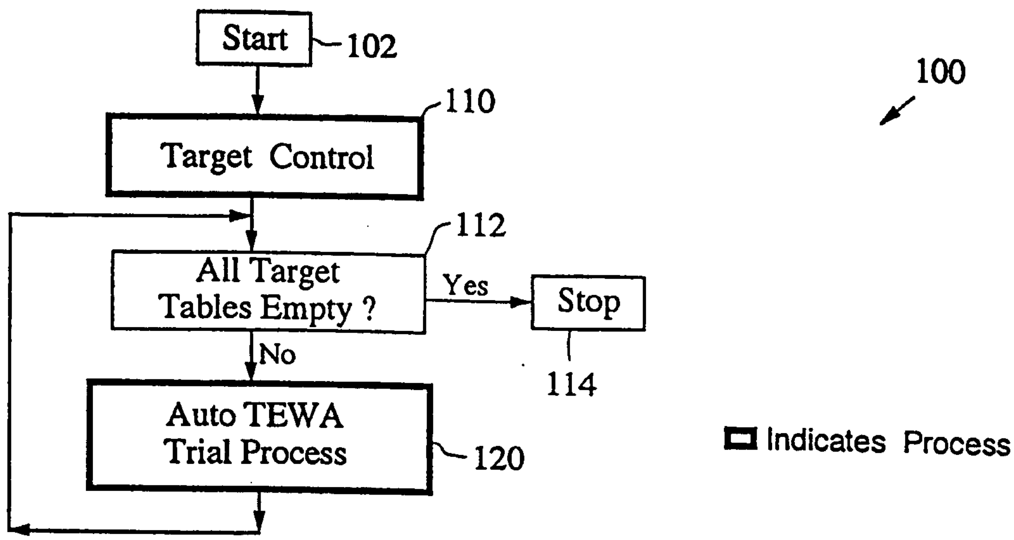

Start
102
100
Target Control
110
All Target Tables Empty ?
112
Yes
Stop
114
No
Auto TEWA Trial Process
120
Indicates Process

FIG. 5

FIG. 6

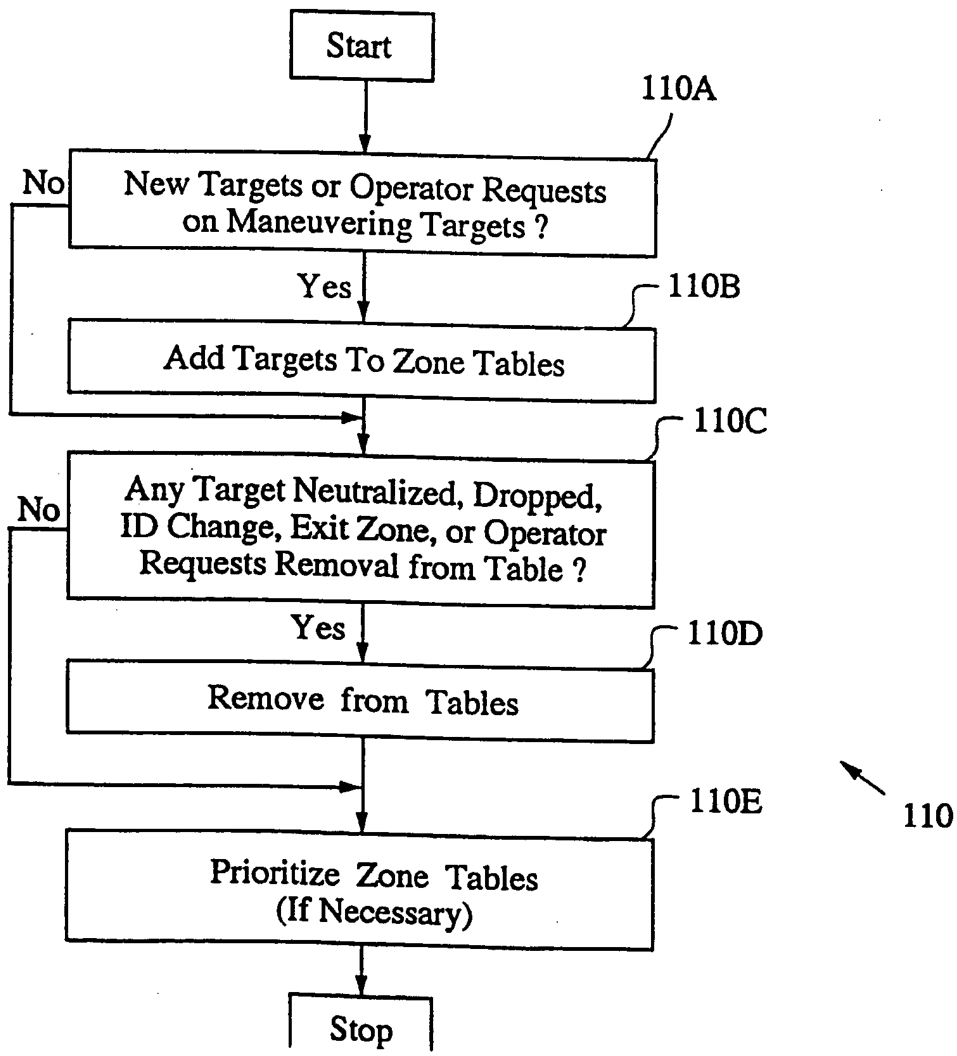

Start
110A
New Targets or Operator Requests on Maneuvering Targets ?
No
Yes
110B
Add Targets To Zone Tables
110C
Any Target Neutralized, Dropped, ID Change, Exit Zone, or Operator Requests Removal from Table ?
No
Yes
110D
Remove from Tables
110E
110
Prioritize Zone Tables (If Necessary)
Stop

FIG. 7

Target Type	Priority 1	Weapon 2	Types 3	• • •	Zone 4 Target Priority
MIG X-L3	F16-L1	F16-L2	IHAWK	• • •	2
MIG Y	F16-L2	F16-L1	PATRIOT	• • •	1
HELO Z	F16-L2	F16-L1	IHAWK	• • •	3
• • •					
Unknown	F16-L2	F16-L1	IHAWK	• • •	4

List All Possible Target Types

40

Note: Table Required for Each Zone

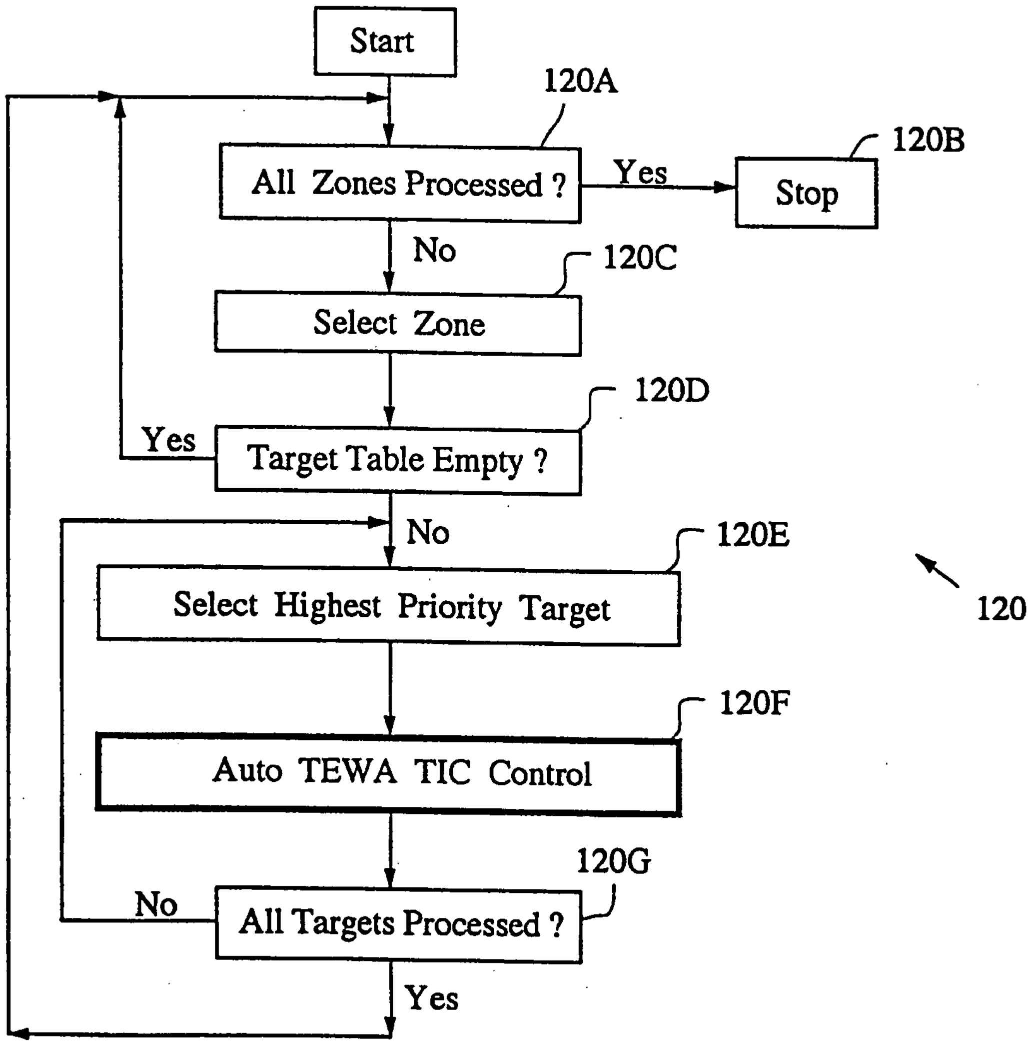

Start
120A
All Zones Processed ?
Yes
Stop
120B
No
120C
Select Zone
120D
Yes
Target Table Empty ?
No
120E
Select Highest Priority Target
120
120F
Auto TEWA TIC Control
120G
No
All Targets Processed ?
Yes

FIG. 8

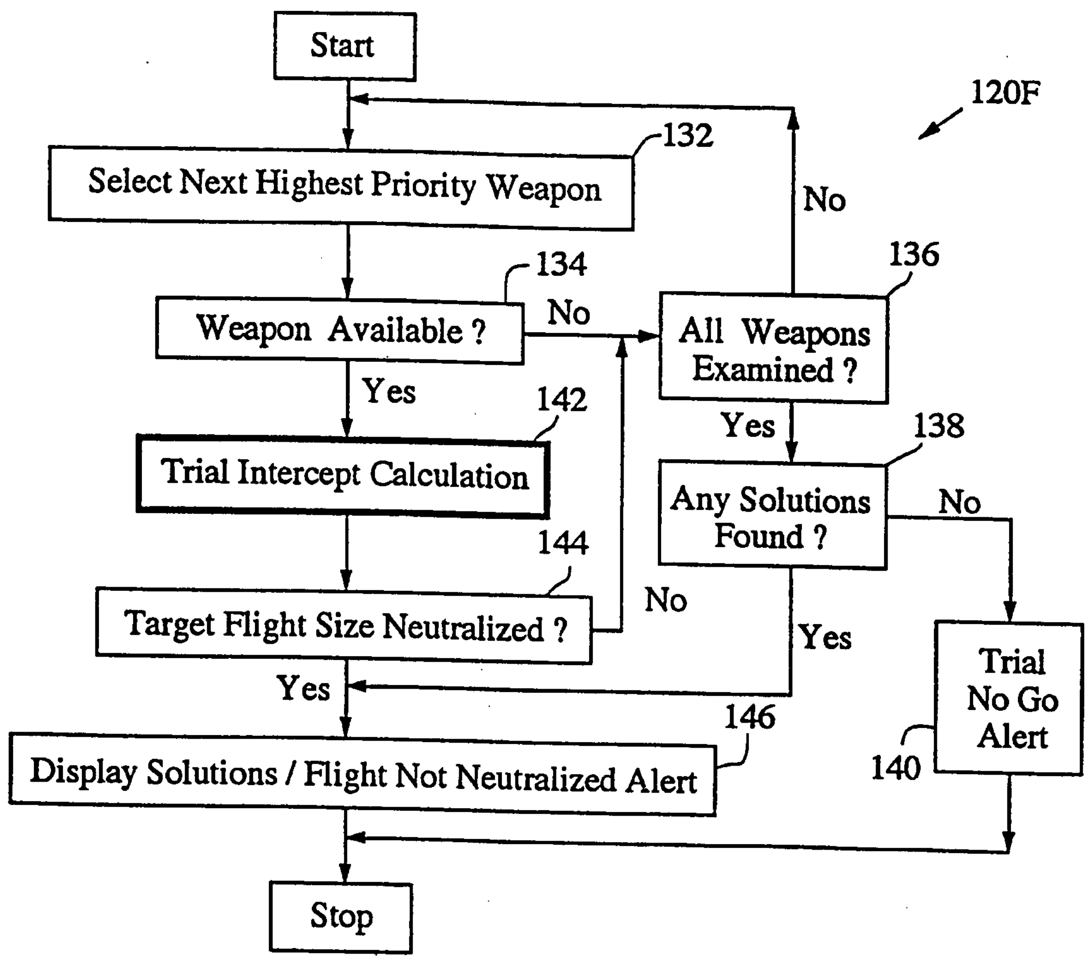

Start
120F
132
Select Next Highest Priority Weapon
No
134
136
Weapon Available ?
No
All Weapons Examined ?
Yes
142
Yes
138
Trial Intercept Calculation
Any Solutions Found ?
No
144
No
Target Flight Size Neutralized ?
Yes
Trial No Go Alert
Yes
146
140
Display Solutions / Flight Not Neutralized Alert
Stop

FIG. 9

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 98/22350

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F41G3/04 F41G5/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F41G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 511 218 A (CASTELAZ PATRICK F) 23 April 1996 see abstract see column 3, line 11 - column 6, line 19; figures 1-5 ---	1,5
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 280 (P-1547), 28 May 1993 & JP 05 012293 A (NEC CORP), 22 January 1993 see abstract ---	1,5
A	DE 38 18 444 A (SIEMENS AG) 7 December 1989 see abstract see page 2, line 29 - page 5, line 21; figures 1-4 --- -/--	1,5

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 January 1999	04/02/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Blondel, F

2

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 98/22350

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 647 759 A (WORSHAM RICHARD H ET AL) 3 March 1987 see abstract see column 2, line 61 - column 17, line 41; figures 1-6	1,5
A	WO 95 19545 A (HONEYWELL INC) 20 July 1995 see abstract see page 3, line 4 - page 5, line 17; figures 1-3	1,5
X,P	WO 98 09131 A (BROUWER JAN KLAAS ;HOLLANDSE SIGNAALAPPARATEN BV (NL)) 5 March 1998 see abstract see page 5, line 21 - page 10, line 10; figure	1,5

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/22350

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5511218 A	23-04-1996	NONE	
DE 3818444 A	07-12-1989	NONE	
US 4647759 A	03-03-1987	NONE	
WO 9519545 A	20-07-1995	CA 2181458 A	20-07-1995
		EP 0740773 A	06-11-1996
		JP 9507713 T	05-08-1997
WO 9809131 A	05-03-1998	NL 1003873 C	03-03-1998
		AU 4208697 A	19-03-1998